

Multiple Pathways to Learning Engagement in MOOCs: A Configurational Analysis Using FSQCA for Inclusive Digital Learning in Postgraduate Education

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ABSTRACT:

The increasing complexity of digital learning environments challenges traditional linear approaches to understanding learner engagement in Massive Open Online Courses (MOOCs). This study adopts fuzzy-set Qualitative Comparative Analysis (fsQCA) to examine how different configurations of environmental and cognitive factors contribute to high learning engagement among postgraduate students. Five key conditions are analyzed: Learning Environment Support (LES), Perceived Usefulness (PU), Satisfaction (SAT), Intrinsic Motivation (IM), and Self-Regulated Learning (SRL).

Using data collected from 432 postgraduate students enrolled in MOOCs-integrated courses, the study identifies multiple configurational pathways leading to learning engagement. The results indicate that LES functions as a quasi-necessary condition, while engagement emerges through three distinct pathways: system-driven, motivation-driven, and hybrid configurations. Among these, the hybrid pathway—combining strong environmental support with high intrinsic motivation and self-regulated learning—produces the highest level of engagement. The findings demonstrate key principles of complexity theory, including equifinality, causal asymmetry, and conjunctural causation.

Importantly, this study advances MOOC research by shifting from variable-centered explanations to a configurational perspective, emphasizing that learning engagement arises from multiple interacting conditions rather than isolated factors. In alignment with Sustainable Development Goal 4 (SDG 4), which promotes inclusive and equitable quality education, the identification of multiple learning pathways highlights the need for flexible and adaptive digital learning systems that accommodate diverse learner needs. The findings provide practical implications for designing

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inclusive and personalized MOOC environments in postgraduate education.

Keywords: MOOCs, fsQCA, configurational analysis, learning engagement, complexity theory, inclusive learning, postgraduate education

1. Introduction

The proliferation of Massive Open Online Courses (MOOCs) has fundamentally reshaped the landscape of higher education by enabling unprecedented levels of accessibility, scalability, and flexibility in learning. Universities worldwide have increasingly integrated MOOCs into formal postgraduate curricula as part of broader digital transformation strategies aimed at promoting lifelong learning and the democratization of knowledge. This transformation is increasingly supported by collaborative leadership models that foster integration between institutional systems, stakeholders, and learning environments, thereby enhancing adaptive and systemic learning processes in higher education (Qiumeng et al., 2025). Despite these advancements, fostering and sustaining meaningful learner engagement remains a critical challenge. Recent evidence suggests that learner engagement in digital environments is increasingly influenced by motivational support, adaptive interaction, and personalized learning experiences facilitated by emerging technologies (Zheng & Wardzala, 2020; Hashmi et al., 2025).

A substantial body of prior research has sought to explain learner engagement and continuance intention in MOOCs using variable-centered approaches, particularly regression analysis and structural equation modeling (SEM). These studies have identified key determinants such as perceived usefulness, satisfaction, and intrinsic motivation as significant predictors of learning outcomes (Alraimi et al., 2015; Joo et al., 2018). While these findings provide valuable insights, they are grounded in the implicit assumption of linearity and causal symmetry, where relationships among variables are treated as additive, independent, and uniform across individuals (Ragin, 2008).

However, such assumptions may not adequately capture the inherent complexity and heterogeneity of digital learning processes. In practice, MOOC learners do not follow a single, uniform pathway toward engagement. Instead, they navigate diverse learning trajectories shaped by the dynamic interplay of environmental conditions, cognitive evaluations, and behavioral strategies. For example, highly self-regulated learners may sustain engagement despite limited institutional support, whereas others may rely heavily on well-structured digital environments to maintain participation. These contrasting scenarios suggest that similar outcomes may arise from fundamentally different causal mechanisms, thereby challenging the explanatory power of traditional linear models.

To address these limitations, this study adopts a complexity-informed perspective grounded in complexity theory to reconceptualize learning engagement in MOOCs. Complexity theory posits that social phenomena do not result from isolated causal effects but emerge from nonlinear and interdependent interactions among multiple conditions (Byrne, 2013). Three core principles are particularly relevant in this context. First, equifinality suggests that multiple pathways can lead to the same outcome. Second, causal asymmetry implies that the factors leading to high engagement may differ fundamentally from those leading to low engagement. Third, conjunctural causation emphasizes that outcomes arise from specific combinations of conditions rather than from single independent variables (Ragin, 2008; Misangyi et al., 2017).

Building on this theoretical foundation, the present study employs fuzzy-set Qualitative Comparative Analysis (fsQCA) as an analytical approach capable of capturing such causal complexity. Unlike traditional symmetric methods, fsQCA is case-oriented and configurational, enabling the identification of

both necessary conditions and sufficient combinations (causal recipes) that produce a given outcome (Fiss, 2011). This approach is particularly well-suited to MOOC research, where learner diversity, technological variability, and contextual differences give rise to multiple pathways toward engagement.

Furthermore, this study extends prior MOOC research by shifting the analytical focus from identifying “which factors matter most” to examining “how different conditions combine to produce engagement under varying circumstances.” This shift is not only methodological but also epistemological, as it challenges reductionist models and promotes a more holistic understanding of digital learning as a configurational and context-dependent phenomenon (Woodside, 2013).

Accordingly, the objective of this study is to examine configurational pathways leading to learning engagement in MOOCs among postgraduate students. By adopting a configurational lens, the study aims to uncover multiple, coexisting causal patterns that explain how engagement emerges under different conditions. In doing so, it contributes to the literature by advancing methodological pluralism in educational research through the application of fsQCA.

2. Theoretical Background

2.1 Complexity Theory and Educational Processes

Complexity theory posits that educational outcomes do not arise from

single causal variables but emerge from dynamic, adaptive, and non-linear interactions among environmental conditions, learners, and behavioral processes (Byrne, 2013). In the context of MOOCs, learning engagement is shaped by the interplay of system capabilities, content quality, intrinsic motivation, and self-regulated learning strategies. Improvements in a single condition may produce disproportionate effects depending on the presence or absence of other conditions.

Three core principles are particularly relevant:

- **Conjunctural causation:** Outcomes result from combinations

of conditions rather than isolated variables (Ragin, 2008).

- **Equifinality:** Multiple pathways can lead to the same outcome,

implying that learning design must remain flexible (Misangyi et al., 2017).

- **Causal asymmetry:** The factors leading to success are not

simply the inverse of those leading to failure.

These principles underscore the need for a configurational approach to

better explain complex and context-dependent patterns of learning engagement.

2.2 Configurational Approach and fsQCA

The configurational approach emphasizes combinations of conditions

rather than isolated variables in explaining outcomes (Fiss, 2011).

- Fuzzy-set Qualitative Comparative Analysis (fsQCA)

enables the identification of both necessary conditions and sufficient configurations (Ragin, 2008).

- It is particularly suitable for MOOC contexts, where

engagement emerges from different combinations of Learning Environment Support (LES), Perceived Usefulness (PU), Satisfaction (SAT), Intrinsic Motivation (IM), and Self-Regulated Learning (SRL) across individuals and contexts.

- The method explicitly accommodates equifinality and causal

asymmetry, allowing for the identification of multiple pathways to engagement as well as configurations associated with its absence.

A key advantage of fsQCA lies in its ability to integrate quantitative

rigor with qualitative sensitivity, using fuzzy sets to capture degrees of membership and enabling systematic cross-case comparisons (Woodside, 2013).

2.3 Conceptual Framework

Table 2. Key conditions and definitions

Variable	Description
LES	Learning Environment Support, including LMS functionality and institutional support
PU	Perceived usefulness of MOOCs for academic performance
SAT	Satisfaction with the learning experience
IM	Intrinsic motivation for engagement driven by interest and enjoyment
SRL	Self-regulated learning, including planning, monitoring, and control of learning

The interaction of these conditions produces multiple pathways to high engagement, for example:

- System-driven pathway: LES + PU + SAT
- Learner-driven pathway: IM + SRL (with LES as a peripheral condition)
- Hybrid pathway: LES + IM + SRL

This framework aligns with the principles of complexity theory by emphasizing interaction, heterogeneity, and context dependence, and provides the foundation for applying fsQCA to identify configurational pathways to learning engagement in MOOCs.

3. Methodology

This study adopts a configurational research design grounded in complexity theory and employs fuzzy-set Qualitative Comparative Analysis (fsQCA) as the primary analytical method. This approach enables the examination of causal complexity, including equifinality, conjunctural causation, and causal asymmetry (Fiss, 2011; Ragin, 2008).

Data were collected from 432 postgraduate students enrolled in MOOC-integrated courses

Drawing on complexity theory and the configurational approach,

learning engagement (LE) in MOOCs is conceptualized as an emergent outcome of interactions among five key conditions.

using a purposive sampling strategy to ensure that all participants had direct experience with MOOCs.

The study examines the following conditions

- Learning Environment Support (LES): structural and environmental support for learning
- Perceived Usefulness (PU): learners' perceptions of the usefulness of MOOCs
- Satisfaction (SAT): affective responses to the learning experience
- Intrinsic Motivation (IM): internal motivation to engage in learning
- Self-Regulated Learning (SRL): learners' ability to plan, monitor, and regulate their learning processes

The outcome variable is:

- Learning Engagement (LE): encompassing behavioral, cognitive, and emotional engagement

All constructs were measured using a five-point Likert scale. Measurement quality was confirmed, with Cronbach's alpha and composite reliability exceeding 0.70, and average variance extracted (AVE) exceeding 0.50.

Calibration followed the direct method proposed by Ragin (2008), transforming Likert-scale data into fuzzy-set membership scores. Three qualitative anchors were defined: full membership (0.95), crossover point (0.50), and full non-membership (0.05).

The fsQCA analysis was conducted in two stages:

1. Necessary Condition Analysis: identifying conditions required for high engagement (consistency ≥ 0.90)

2. Truth Table and Configurational Analysis: constructing a truth table to

identify sufficient configurations (consistency ≥ 0.80 ; minimum frequency = 3) and distinguishing between core and peripheral conditions

Robustness and validity were assessed through sensitivity analysis, evaluation of solution consistency and coverage, and examination of causal asymmetry for both the presence and absence of high engagement.

This approach enables the identification of multiple configurational pathways to learning

engagement in MOOCs while accounting for heterogeneity across learners and learning contexts.

4. Results

The fsQCA analysis of data collected from 432 postgraduate students reveals the causal complexity underlying learning engagement (LE) in MOOC contexts. The findings indicate that engagement cannot be explained by single variables; rather, it emerges from configurations of interacting conditions.

In the first stage, the Necessary Condition Analysis, following the approach of Ragin, shows that Learning Environment Support (LES) demonstrates a high level of consistency (≈ 0.90), indicating its role as a quasi-necessary condition for achieving high learning engagement. However, its limited coverage suggests that LES alone is insufficient to produce the outcome, consistent with the principle of causal asymmetry in complexity theory.

Subsequently, the configurational analysis identifies multiple pathways (equifinality) leading to the same outcome. These can be categorized into three primary configurations: system-driven, motivation-driven, and hybrid pathways. This highlights that learning engagement emerges from the interaction between system-level and individual-level factors.

Table 2. Configurational pathways to high learning engagement

Pathway Type	Core Conditions	Description
System-driven	LES + PU + SAT	A well-supported system enhances perceived usefulness and satisfaction, leading to engagement
Motivation-driven	IM + SRL	Learners with strong intrinsic motivation and self-regulation achieve engagement even with limited system support
Hybrid	LES + IM + SRL	The combination of a supportive system and capable learners produces the highest level of engagement

From an analytical perspective, the findings suggest that:

(1) learning engagement does not depend on any single factor;

(2) the learning environment functions as a foundational condition in MOOC systems; and

(3) optimal outcomes are achieved when system-

level and individual-level factors interact synergistically.

These findings reflect the concept of a digital learning ecosystem, emphasizing alignment

between system structures and learner behaviors. Moreover, they confirm that a configurational approach provides a more robust explanation of learning complexity in MOOCs than traditional linear methods.

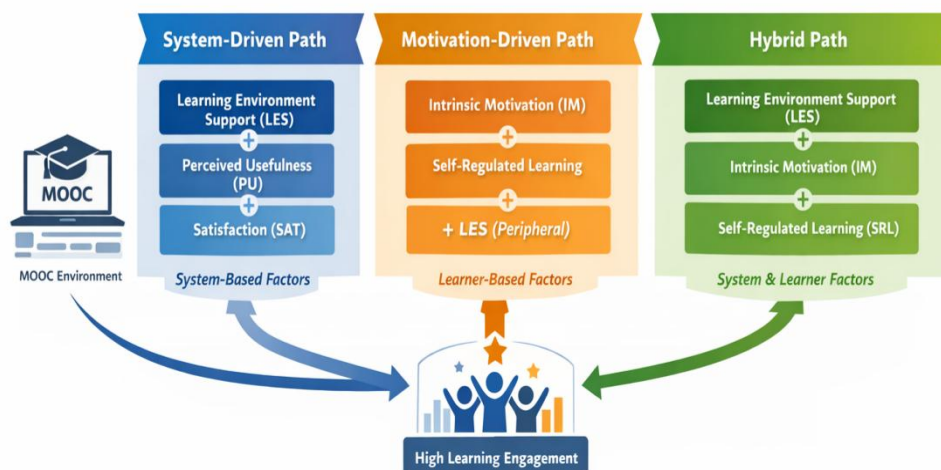


Figure 1. Pathways to Learning Engagement in MOOCs

5. Discussion

The findings indicate that learning engagement (LE) in MOOCs is characterized by causal complexity and cannot be explained by single factors alone. The configurational analysis reveals the presence of multiple pathways leading to the same outcome (equifinality), reflecting the diversity of learners and patterns of digital system usage.

First, the system-driven pathway demonstrates that Learning Environment Support (LES), Perceived Usefulness (PU), and Satisfaction (SAT) jointly contribute to engagement. This finding aligns with the Expectation-Confirmation Model (Bhattacharjee, 2001) and prior studies (Alraimi et al., 2015), which emphasize the mediating roles of perceived value and satisfaction in sustaining learning continuance.

Second, the motivation-driven pathway highlights the role of Intrinsic Motivation (IM) and Self-Regulated Learning (SRL), which can generate engagement even in the absence of strong system support. Emerging evidence also suggests that AI-supported pedagogical approaches can strengthen these mechanisms by providing adaptive feedback and personalized

learning pathways (Kumari et al., 2025; Borromeo et al., 2025).

This result supports Self-Determination Theory (Deci & Ryan, 1985) and empirical findings by Joo et al. (2018), indicating that motivation and self-regulation are critical drivers of sustained learning.

Third, the hybrid pathway, combining LES, IM, and SRL, emerges as the most effective configuration. This suggests that engagement is maximized when supportive system structures are aligned with learners' capabilities and motivations. This finding is consistent with the socio-technical systems perspective (Bandura, 1986; Bostrom & Heinen, 1977), which posits that outcomes arise from the alignment between technological systems and human factors.

In summary, this study confirms that learning engagement in MOOCs is configurational and non-linear in nature. No single factor is sufficient on its own; rather, engagement emerges from the interaction of multiple conditions, consistent with the concept of a digital learning ecosystem, which emphasizes the balance and alignment between system design and learner characteristics. From a sustainability perspective, these findings

contribute to the advancement of Sustainable Development Goals by demonstrating how digital learning ecosystems can promote inclusive, adaptive, and high-quality education. In particular, the integration of technological innovation and learner-centered design supports SDG 4 (Quality Education) and SDG 9 (Industry, Innovation and Infrastructure), while the interaction between institutional and learner-level factors reflects the importance of partnerships emphasized in SDG 17 (United Nations, 2015).

6. Implications and Future Research

6.1 Theoretical Implications

This study advances MOOC research by demonstrating that a

configurational approach provides a more robust explanation of engagement than traditional linear methods such as SEM (Alraimi et al., 2015; Joo et al., 2018). The findings highlight that outcomes arise from the combined effects of multiple conditions, consistent with the principles of conjunctural causation and equifinality in complexity theory (Byrne, 2013).

Notably, the identification of the hybrid pathway underscores that the

highest levels of engagement occur through the alignment of system-level and individual-level factors, supporting the socio-technical systems perspective (Bandura, 1986; Bostrom & Heinen, 1977). Furthermore, the results demonstrate that the concept of a digital learning ecosystem can be empirically operationalized and tested, rather than remaining purely theoretical.

6.2 Practical Implications

From a practical perspective, several recommendations can be derived:

- MOOC platforms and Learning Management Systems (LMS) should be designed to be flexible, accommodating both highly self-directed learners and those requiring substantial system support.
- Institutions should develop integrated features such as single

sign-on systems, unified dashboards, and accessible resource repositories.

- Learning activities should be designed to enhance intrinsic

motivation and self-regulated learning, including self-assessment, goal-setting, and peer feedback mechanisms.

- Personalized learning approaches should be implemented to

address diverse learner needs. In this context, generative AI tools can be leveraged to design adaptive learning systems that provide personalized content, feedback, and learning pathways aligned with individual learner needs (Borromeo et al., 2025).

- MOOCs should be formally integrated into academic credit

systems. Such integration requires collaborative leadership and institutional partnerships capable of connecting learning ecosystems, workforce development, and digital innovation strategies (Qiumeng et al., 2025).

- Institutions should provide incentives for sustained

engagement, such as digital badges, micro-credentials, and formal certification.

6.3 Limitations and Future Research

This study has several limitations.

First, the data were collected from a single university, which

may limit the generalizability of the findings. Future studies should include multiple institutions to validate the identified configurations.

Second, the cross-sectional nature of the data may not fully

capture the dynamic evolution of learning engagement. Future research should adopt longitudinal designs to examine how configurational pathways develop over time.

Finally, future studies should incorporate additional outcome

variables such as academic performance, skill acquisition, and learning satisfaction to provide a

more comprehensive understanding of learning effectiveness in MOOCs.

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